

## INTRODUCTION TO MATHCAD

### More on Vectors and Matrices

We saw in a previous lesson how we could create vectors and matrices using the Vectors & Matrices palette. This is a useful way when we want to manually create a matrix or vector. We would typically do this if we wanted to enter a small amount of experimental data into a vector.

Often, though, we need Mathcad to automatically create a matrix, vector or list of numbers based on some criteria you have calculated elsewhere in your worksheet. We can make Mathcad create a matrix or vector if we define a variable and use subscripts.

We also use those subscripts if we need to access an individual element from a matrix or vector.

Recall that a vector (in Mathcad) is simply a matrix with one row or one column. In this lesson we will use the term “vector” to mean a matrix that is just a single row or a single column. We will use the term “matrix” to mean any form of matrix, irrespective of the number of rows or columns.

Start a new worksheet before proceeding with this lesson.

Later you will need to format the worksheet as an enclosure. What's the quick way? If you forgot, go back and check the “*Basic Concepts*” tutorial.

**CREATING A VECTOR USING SUBSCRIPTS:** Subscript notation can be useful in creating vectors and matrices and will often be useful in addressing individual elements of the matrix. We instruct Mathcad to insert a subscript in one of several ways. We can use the ‘ **$X_n$** ’ option in the Matrix palette, or we can use the shortcut keystroke **[**. Try the following. In this lesson we use the shortcut keystroke, but you should practice using both the shortcut and the Matrix palette.

**$x[ 2:5$**   
 **$x =$**

The result is a column vector with three elements whose values are 0, 0, and 5 respectively. Why three elements?

Mathcad assumes that the first row or column is the zero<sup>th</sup> row or column. Thus when you enter the value of 5 for  $x_2$  (and no values have been defined for  $x_0$  and  $x_1$ ) Mathcad creates a new vector. It assigns ‘5’ to the  $x_2$  position, and inserts zero for  $x_0$  and  $x_1$ .

If you wanted to define a vector whose components are 2, 3, 5 ( $x_0$ ,  $x_1$ ,  $x_2$  respectively),

you could do this by typing the following (one per worksheet region). Type the following *before* the **x=** region in your worksheet and see what happens.

**x[ 0:2      x[ 1:3      x[ 2:5**

Now let's 'extract' a single value from the vector. We will use variable 'i' to identify which element of the matrix we want to see. Below the previous assignments, type the following:

**i:2  
x[ i=**

You should get the answer '5'. Try successively changing 'i' to take the values 0 and 1 and check you are extracting the correct values from the vector.

What happens if you make 'i' be less than zero or bigger than 2? Try it. The 'i' in the **x[** should turn red. Click on the red 'i' and read the Mathcad error message.

In place of using subscripts to create a vector, you could have manually created a 3x1 matrix and entered the values at the placeholders. Generally speaking, the subscript approach is more cumbersome when defining a full matrix, but the subscript notation is more efficient when defining a specific element.

**MATRICES:** Matrices are defined using two subscripts. Thus the Mathcad code

**A[ 2,2:5**

defines a 3x3 matrix whose elements  $A_{i,j}$  are each zero except for  $A_{2,2} = 5$ . Type **A=** to see the matrix.

**THE ORIGIN:** As you saw, Mathcad assumes the first element in a vector or the first row and first column of a matrix is the zero<sup>th</sup> element (that is, it's index is zero). This is just Mathcad's default setting, and you can change it using the Mathcad command ORIGIN. The command must be typed in UPPER CASE. The number you give resets the enumeration for the first row and column.

Start a new worksheet. Near the top of the worksheet, type in the following (the tilde '~' is at the top-left of the keyboard):

**ORIGIN~0**

It will appear on your worksheet as ORIGIN=0. Now use the **Matrix palette** to manually define a matrix, B, with 3 rows and 3 columns. Enter different numbers into each placeholder.

After your definition of the matrix, type in **B[ 1,2=** and you should get the number you entered in the second row (whose index is 1) and the third column (whose index is 2).

Change the ORIGIN command so that it is

### **ORIGIN~1**

Notice that the  $B_{1,2}$  element that is returned is now from the first row, and the second column. The ORIGIN command changes the starting index for every matrix and array in your worksheet.

Remember that Mathcad works “*left-to-right, top-to-bottom*”? What do you think will happen if you move the ORIGIN~1 region below the B matrix regions? Try it.

Were you surprised?

You should use ONLY ONE ORIGIN~ command in each worksheet.

The ORIGIN~ command works FOR THE ENTIRE WORKSHEET, irrespective of where you place it.

This can be a ‘dangerous’ command, so use it with caution!

Rearrange your work for this tutorial so that it fits on a single page. Add some text boxes to explain what the work is about. Put your name at the top of the worksheet, and format your worksheet as an Enclosure.

Save your work to file **Mcad\_Matrix\_01**

SUBMIT to your instructor:

Print the single page worksheet and submit it to your instructor.

Close Mathcad.

This introduction to Vectors and Matrices is finished!